DOCUMENT RESUME

ED 238 949 TM 840 066

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TITLE Development of Size Judgement Ability among Down Syndrome and Normal Children.
PUB DATE Jul 83
NOTE 28p.; Paper presented at the Biennial Meeting of the International Society for the Study of Behavioural Development (7th, Munich, West Germany, July 31-August 4, 1983).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Cognitive Measurement; *Downs Syndrome; Elementary Secondary Education; *Intelligence Quotient; Intelligence Tests; Perception Tests; *Performance Factors; Predictor Variables; Short Term Memory; *Test Format; Testing Problems; *Time

ABSTRACT

Many tests which attempt to produce intelligence quotient or mental age scores for children rely on time taken to complete the task for a valid result to be obtained. A number of tests were carried out with both Down's Syndrome and normal children (128 Down's Syndrome; 162 normal) in order to determine (1) relative abilities to complete the tasks according to chronological age and mental age (2) time taken to complete the tasks. The results indicate that there is no relationship in cognitive and perceptual tasks between ability and time taken in Down's Syndrome children, though in normal children there is a clear relationship. It is therefore suggested that time is not a dimension which can be usefully employed in determining intellectual levels of Down's Syndrome children. It is further suggested that the reasons might be more related to personality and temperamental differences than cognitive and perceptual abilities. (Author)

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DEVELOPMENT OF SIZE JUDGEMENT ABILITY AMONG DOWN SYNDROME AND NORMAL CHILDREN

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INTERNATIONAL SOCIETY FOR THE STUDY OF BEHAVIOURAL DEVELOPMENT

Seventh Biennial Meetings - July 31 - August 4, 1983
University of Munich, W. Germany (FRG)

TM 840 066

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Summary

Many tests which attempt to produce I.Q. or M.A. scores for children rely on time taken to complete the task for a valid result to be obtained. A number of tests were carried out with both D.S. and normal children (128 Down's Syndrome; 162 normal) in order to determine (a) relative abilities to complete the tasks according to C.A. and M.A. and (b) time taken to complete the tasks. The results indicate that there is no relationship in cognitive and perceptual tasks between ability and time taken in D.S. children, though in normal children there is a clear relationship. It is therefore suggested that time is not a dimension which can be usefully employed in determining intellectual levels of D.S. children. It is further suggested that the reasons might be more related to personality and temperamental differences than cognitive and perceptual abilities.

The performance of Down Syndrome subjects on perceptual and cognitive tasks, both standardised and specially designed, has been the subject of a number of investigations (O'Connor & Hermelin, 1962; Zeaman & House, 1962; Gibson, 1966 & 1978; Stratford & Alban Metcalfe, 1981 & 1982; Morss, 1983; Alban Metcalfe & Stratford, 1983). Of these, four studies were concerned with the development of perceptual or cognitive abilities. Thus, Zeaman and House suggested that a continuous, but non-linear relationship exists between chronological age (CA) and mental age (MA) among Down Syndrome children, whereas Gibson reported a series of three plateaux in the development of intellectual ability between CA 2:0 and 16:6 years.

In contrast, Alban Metcalfe and Stratford found that the relationship between CA and scores on the PPVT was significantly linear, with no evidence of significant non-linearity, between CA range 5:6 and 17:9 years (MA range 2:3 to 10:7 years). Furthermore, they also found significantly linear relationships between both CA and MA and performance on a visual perceptual task and a task involving short-term visual memory, again with no evidence of significant non-linearity.

These last results were interpreted as suggesting that essentially similar perceptual and cognitive processes were taking place on these tasks when performed by normal and Down Syndrome subjects. Indeed, on the perceptual task, there was evidence that the performance of the Down Syndrome subjects was superior overall to that of a group of normal subjects, matched for MA. On the other hand, Morss presented evidence to suggest that on Piagetian sensory-motor tasks, Down Syndrome children perform in a way that is qualitatively different to normal children.

This present paper is also concerned with performance on (i) a visual perceptual task, and (ii) a task involving short-term memory for visual stimuli. In this case, however, (a) the stimuli were different from those reported previously, and (b) performance was measured in terms of time to

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complete the task, rather than placing importance on the number of correct responses.

METHOD

Subjects

The subjects were 128 Down Syndrome children and 162 normal children, all attending day school and living at home. The children were matched on mental age (P.P.V.T., Dunn, 1965) which fell within the range 2:3 - 11:3 years. (Down Syndrome mean, 4.54, s.d., 1.73: normal mean, 5.72, s.d., 1.89). The chronological age range of the Down Syndrome children was 6.4 - 17.9 (mean 11.9, s.d., 2.98) and that of the normal children was 3.6 - 8.2 (mean 5.65, s.d., 1.49).

Procedure

Two different, yet related, visual perceptual tasks were administered. Both tests were repeated involving short term memory for each type of task. The results of the first task were taken as an entirely separate kind of investigation and these have been reported elsewhere (Alban Metcalfe & Stratford, 1983), though these results were used as an independent measure in the present investigation. Consequently the procedure will be briefly outlined here. This will be referred to as MAT:A (for the matching task) and MEM:A (for the memory task). It must be stressed that these tasks were wholly independent of the subsequent tasks and also that they were untimed.

The second test, and the one used for the main purpose of this present study will be referred to as MAT:T and MEM:T.

MAT:A and MEM:A

The subjects were required to match an open display of three cards in all six permutations as shown in the example in Diagram A. The same test was repeated but with the stimulus display being covered after the subject had been encouraged to observe it for approximately 10 seconds. The subject was then required to produce the arrangement from memory.

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MAT:T and MEM:T

These tasks were designed to determine the ability of the subjects to judge differences in sizes of closely related stimuli. A red card was placed on a white board in front of the subject. Then two cards were placed in front of this, one corresponding to the first (stimulus) card, (Diagram T). The subject was asked to point to the card which was the same size as the stimulus card (12.5 x 12.5c.m.; 14.5 x 14.5c.m.; 16.5 x 16.5c.m.). Each card was given three presentations as the stimulus card: e.g. Card 1 = stimulus card; examiner presents for selection, cards 1 and 2, then 2 and 1 and finally 1 and 2 again before changing the stimulus card. Therefore there were nine variations with varying sized cards; the proportional difference remained the same.

The procedure was repeated as a test of short term memory for visual images related to size. The stimulus card was shown to the subject for ten seconds while the 'choice' cards were concealed under a white card. The white card was then transferred to conceal the stimulus card, and the subject was required to point to the card which was the same size as the one he had been looking at.

In both exposed and concealed aspects of the task, the time was recorded, in seconds, from (a) the placing of the choice cards, and (b) the concealing of the stimulus card. The time was recorded independently by an assistant with a stop watch.

It is always difficult in tasks involving pointing, with very young or mentally handicapped children, to decide whether a valid correct or incorrect response has been made, or whether the child is behaving in a random manner. Sometimes it is clear that a child is not pointing at all, but this shades off imperceptibly into behaviour which may or may not be valid pointing. In the tasks under discussion, random pointing would have a 50/50 chance of success. As each child had nine separate attempts, he was treated as a random responder on the series unless he made at least four correct responses.

Results

Interestingly enough, there were very few random responders in either of these large groups. MAT:T task produced 3 random responders from the normal group and 4 from the Down Syndrome group. MEM:T produced 7 from the normal group and 9 from the Down Syndrome group. These subjects were eliminated from the sample. They may of course have been responding at random for some other reason than inability to do the task, e.g. perseveration on pointing to left or right.

Neither group appeared to find difficulty with the task itself and very few errors were made in the MAT:T task; a mean error rate of 0.08 in the normal group and 0.07 in the Down Syndrome group. Though there was obviously no significant difference between the groups in this first part of the test, the MEM:T task, as might be expected, did produce a signficant difference in error rate (0.17:0.32) $p < 0.05$, Scheffé's test.

Attention was turned to developmental aspects of speed of performance of response, as it was here that highly significant differences were detected between the groups. MAT:T and MEM:T results were now only considered in terms of time taken to complete the task, correctly or incorrectly.

In order to test for the possibility of developmental trends, the subjects in each group were subdivided into subgroups with reference (a) to CA; (b) to P.P.V.T. scores; (c) to performance on the visual perceptual task, MAT:A. (Mean scores for MAT:A and MEM:A were reported by Alban Metcalfe & Stratford, 1983). (d) to performance on the short-term visual memory task, MEM:A. For both CA and P.P.V.T. scores, four equidistant cut-off points were chosen which would attempt to ensure a minimum of 20 subjects in each subgroup. The same cut-off points were chosen for P.P.V.T. scores for both normal and Down Syndrome subjects, but it was necessary to choose different CA cut-off points, owing to differences in the CA ranges of the two groups of subjects. Subjects were subdivided with reference to scores on the MAT:A and MEM:A tasks.

1. Relationships between CA and times for MAT:T and MEM:T tasks

Relationships between mean times taken to complete the MAT:T and MEM:T tasks and CA were examined by one-way ANOVA, using a programme devised by Youngman (1976) (Table 1 and Figure 1). In the cases of the normal subjects, significant CA related differences were detected in mean scores for both MAT:T ($p < .02$) and MEM:T ($p < .001$) and there was evidence of significant linearity in both cases ($p < .001$). Among the Down Syndrome subjects, significant CA related differences in mean scores were not detected for either MAT:T or MEM:T, though MEM:T scores were found to be significantly linear ($p < .05$). However, it was noted that Bartlett's test for heterogeneity of variance was statistically significant in the cases of MAT:T and MEM:T scores for both normal and Down Syndrome subjects ($p < .001$).

In view of dubeity associated with interpreting ANOVAs for samples where variance vary significantly, specific comparisons were made between mean scores, using Scheffé's test. This is a robust statistic, which does not tend to give 'false positive' results (Youngman, 1979). Only three statistically significant differences were detected. Among normal subjects only, mean MAT:T times for the oldest group were lower than for the youngest group ($p < .05$), and mean MEM:T times for the two oldest groups were also lower than for the youngest group ($p < .01$) in each case). These results can be interpreted as supportive of overall CA related trends among the normal subjects.

2. Relationships between MA and times for MAT:T and MEM:T tasks

Turning to relationships between scores on three tests, independently of CA, both two-way and one-way ANOVAs were performed on the data (Table 2 and Figure 2). Two-way ANOVA of P.P.V.T. scores by groups (normal, Down Syndrome) with MAT:T or MEM:T as the dependent variable suggested only one significant effect ($p < .001$ in each case), interpretable as overall superiority (i.e. lower mean times) in the performance of the normal subjects on each of the tasks, when matched for MA age.

(Table 2 and Figure 2 about here)

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One-way ANOVAs revealed significant differences between mean scores for the subgroups only in the cases of the normal subjects. Here, significant effects were detected for times to complete both the MAT:T and the MEM:T tasks ($p < .05$), and significant linear trends were also detected ($p < .01$). There was, however, no evidence of an interpretable pattern of relationships between MAT:T or MEM:T times and P.P.V.T. scores among the Down Syndrome subjects. Again, Bartlett's test suggested significant heterogeneity of variance, so specific comparisons were again made using Scheffé's test. No significant differences were detected between mean scores for Down Syndrome subjects in the different subgroups. Among the normal subjects, though, mean MAT:T times for the MA 90+ months group were significantly lower than for the MA 54-65 months group ($p < .05$) and MEM:T times for the MA 90+ months group were significantly lower than both the MA up to 53 months and the MA 54-65 months groups ($p < .01$ in each case). The results of the Scheffé tests can be interpreted as supporting the suggestion that a significant overall MA related trend can be detected among the normal subjects.

3. Relationships between MEM:A scores and times for MAT:T and MEM:T tasks

The relationships between scores on these three tests were also examined using two-way and one-way ANOVAs (Table 3 and Figure 3). Two-way ANOVA of MEM:A scores by groups (normal, Down Syndrome) with MAT:T or MEM:T as the dependent variable also suggested only one significant effect ($p < .001$ in each case). In these cases also, there was evidence of overall superiority of the normal subjects when matched for performance on the untimed MEM:A task.

(Table 3 and Figure 3 about here)

One-way ANOVA revealed significant MEM:A related differences in MEM:T times for both normal and Down Syndrome subjects, and MAT:T times only for normal subjects ($p < .05$). In each case, significantly linear trends were also detected ($p < .01$). As previously, variances were significantly heterogeneous, and Scheffe's test was used to make specific comparisons (Table 4 and figure 4).

No significant differences were detected among the Down Syndrome subjects, but among the normal group, the performance of the Group 5 subjects was significantly better tha. that of the Group 4 subjects on the MAT:T task, and of the Group 4 and Group 1 subjects on the MEM:T task ($p < .05$ in each case). The Scheffé test scores can be seen as confirming the existence of an overall performance-related trend in the cases of normal subjects.

(Table 4 and Figure 4 about here)

4. Relationships between MAT:A scores and times for MAT:T and MEM:T tasks

Lastly, two-way and one-way ANOVAs were performed to examine relationships between MAT:T and MEM:T times and scores on the MAT:T task. As previously, the two-way ANOVA suggested significant overall superiority of the normal subject on both the MAT:T and MEM:T tasks, when matched for performance on the MAT:A task ($p < .001$ in each case).

A significant MAT:A related difference was detected only among the normal subjects on the MEM:T task, (using one-way ANOVA ($p < .05$) and there was evidence of significant linearity ($p < .05$). Again, however, Bartlett's test suggested significant heterogeneity of variance, and Scheffe's test reached the 5 percent level of significant only when Group 1 and Group 5 or 6 subjects were compared. Again the results of the Scheffé's test can be interpreted as confirming the existence of a performance-related trend among the normal subjects on the MEM:T task.

DISCUSSION

An initial issue must be considered in the nature of the perceptual and cognitive functioning measured by timing performance on the matching and memory tasks MAT:T and MEM:T. Specifically, it is important to determine the extent to which, among the subjects tested here, timed tasks measure abilities that are comparable with those assessed using the other tasks that were administered. Here, the performance of the normal subjects must be taken as a guide.

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Perhaps the most outstanding feature of both the MAT:T and MEM:T results is the heterogeneity of the variances. When CA, MA, or performance on either of the untimed tasks, MAT:A or MEM:A was the independent variable, Bartlett's test exceeded the 5 per cent significance level. Such a result is interpretable as suggesting that there are very considerable difference between individuals matched with reference to CA or performance on any of the tasks, in the performance under timed conditions. Put more simply, it could be suggested that, at least among the subjects tested here either (a) the timed tasks do not afford very reliable measures of perceptual or cognitive functioning, or (b) the timed and untimed tasks are measuring different aspects of perceptual and cognitive functioning, or (c) both.

The issue of reliability cannot be resolved here, but the possibility that the timed and untimed tasks were measuring different aspects of perceptual or cognitive functioning can be explored further. Thus, as presented in Table 1 and Figure 1, the results of both the MAT:T and MEM:T tasks appear consistent with the suggestion that, among normal subjects in the age range tested, an essentially linear relationship exists between speed of performance and chronological age. Thus, whilst the validity of the ANOVA statistic based on these data is open to question, the results of the more robust Scheffé test are consistent with ANOVA evidence of a significantly linear age-related trend.

When MA was the independent variable (Table 2 and Figure 2), the Scheffé test results were again consonant with the (again questionable) evidence of significant linear relationships with speed of performance on MAT:T and MEM:T tasks, among the normal subjects. Essentially similar results were obtained for both MAT:T and MEM:T when MEM:A was the independent variable: in other words, there was again evidence consistent with the suggestion of linear relationships with performance on an untimed cognitive task. However, when MAT:A was the independent variable, a similar pattern emerged only on the MEM:T task.

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What appears to emerge, then, is evidence of a degree of consistency in the way in which the normal subjects responded to the two timed tasks. Whether CA, MA, or performance on an untimed cognitive task involving short-term recall of visual patterns was the independent variable, performance on the two timed tasks can be interpreted in terms of increasing age or cognitive ability. A similar interpretation can account for the relationship between perceptual ability on the untimed task, MAT:A, and the timed cognitive task, MEM:T but not the timed perceptual task, MAT:T.

Taken together, this evidence can be interpreted as suggesting that the untimed tasks reported here involve perceptual and cognitive abilities that are not demonstrably different from those measured using other cognitive tasks, among normal subjects in the age range tested. Both tasks show CA and cognitive ability-related patterns similar to those reported by Alban Metcalfe & Stratford.

As far as the perceptual tasks, untimed MAT:A and timed MAT:T are concerned, the results can probably best be interpreted in the same way as for age and cognitive ability. The tendency for MAT:T times to decrease with increasing performance on the MAT:A task is consistent with the trends identified elsewhere. The only important difference is that the relationship does not reach the level of statistical significance on either the ANOVA or the Scheffé test.

Stated shortly and simply, the normal subjects performed in all aspects of the various tests reported here as might have been expected. As they grow, in years or intelligence, their ability steadily increases and it takes less time to complete similar tasks. Results from earlier work had given us cause to believe that Down Syndrome children would perform similarly, with wider differences but the trends would correspond. The surprising finding was that Down Syndrome children produced no pattern at all when the dimension of time was introduced. It would be rash to attempt explanations without further research in this area. We can only state with some

confidence that reference to timing does not afford a meaningful dimension for measuring performance in Down Syndrome children at least on tests involving visual perception.

This paper was presented at the Seventh Biennial Meetings of the International Society for the Study of Behavioural Development at the University of Munich, W. Germany (FRG) - July 31st - August 4th, 1983.

TABLE 1: MEANS AND STANDARD DEVIATIONS FOR TIMES (IN SECONDS) TO COMPLETE MATCHING (MAT:T) AND MEMORY (MEM:T) TASKS FOR (a) NORMAL, AND (b) DOWN SYNDROME SUBJECTS, SUBDIVIDED ACCORDING TO CA

(a) NORMAL SUBJECTS

CA (MONTHS)	-53	54-65	66-77	78-89	90-
N	48	30	26	34	24
MATCHING X	5.87	5.40	5.23	4.96	4.55
(MAT:T) s.d.	2.67	1.01	0.64	0.77	0.89
MEMORY X	4.21	3.93	3.42	3.15	3.03
(MEM:T) s.d.	1.80	1.13	0.53	0.54	0.25
P.P.V.T. X	46.79	60.43	76.54	85.15	95.54
s.d.	8.93	12.55	11.78	16.06	18.84

(b) DOWN SYNDROME SUBJECTS

CA (MONTHS)	-107	108-131	132-155	156-169	170-
N	22	27	28	15	35
MATCHING X	9.60	9.01	12.81	12.23	8.03
(MAT:T) s.d.	3.17	3.60	16.94	16.94	3.66
MEMORY X	11.05	6.82	7.62	7.15	6.82
(MEM:T) s.d.	16.68	2.66	4.08	4.91	3.92
P.P.V.T. X	38.96	46.59	56.19	57.25	67.54
s.d.	7.99	15.77	17.82	17.53	23.59

TABLE: 2 MEANS AND STANDARD DEVIATIONS FOR MATCHING (TIME IN SECONDS) AND MEMORY (TIME IN SECONDS) FOR (a) NORMAL, and (b) DOWN SYNDROME SUBJECTS, SUBDIVIDED ACCORDING TO MA

(a) NORMAL SUBJECTS

MA (MONTHS)	-42	43-54	55-66	67-78	79-
N	22	31	24	23	62
MATCHING X (MAT:T)(secs)	5.54	5.98	5.61	5.29	4.78
s.d.	2.24	2.76	1.11	0.60	0.79
MEMORY X (MEM:T)(secs)	4.32	4.36	3.68	3.49	3.06
s.d.	1.28	2.15	0.73	0.37	0.32

(b) DOWN SYNDROME SUBJECTS

MA (MONTHS)	-42	43-54	55-66	67-78	79-
N	47	22	22	20	16
MATCHING X (MAT:T)(secs)	11.99	9.10	10.28	10.11	5.32
s.d.	16.15	3.40	3.73	3.57	3.57
MEMORY X (MEM:T)(secs)	8.94	7.29	7.71	8.09	4.65
s.d.	11.97	2.84	4.30	3.45	3.44

TABLE: 3 MEANS AND STANDARD DEVIATIONS FOR TIMES (IN SECONDS) TO COMPLETE MATCHING (MAT:T) AND MEMORY (MEM:T) TASKS FOR (a) NORMAL, AND (b) DOWN SYNDROME SUBJECTS, SUBDIVIDED ACCORDING TO PERFORMANCE ON MEMORY TASK, MEM:A

(a) NORMAL SUBJECTS

GROUP	1	2	3	4	5
MEM:A SCORES	0-1	2	3	4	5-6
N	27	26	21	36	52
MATCHING X	5.80	5.20	5.33	5.89	4.66
(MAT:T) s.d.	2.00	1.15	0.87	2.50	0.81
MEMORY X	4.28	3.69	3.72	3.91	3.04
(MEM:T) s.d.	1.41	0.72	0.91	1.89	0.27

(b) DOWN SYNDROME SUBJECTS

GROUP	1	2	3	4	5
MEM:A SCORES	0-1	2	3	4	5-6
N	58	29	21	8	11
MATCHING X	10.06	9.19	13.53	9.45	6.13
(MAT:T) s.d.	9.20	4.24	19.24	2.93	3.34
MEMORY X	9.07	7.17	7.41	6.31	4.23
(MEM:T) s.d.	11.01	4.04	2.58	2.10	1.54

TABLE 4: MEANS AND STANDARD DEVIATIONS FOR TIMES (IN SECONDS) TO COMPLETE MATCHING (MAT:T) AND MEMORY (MEM:T) TASKS FOR (a) NORMAL, AND (b) DOWN SYNDROME SUBJECTS, SUBDIVIDED ACCORDING TO PERFORMANCE ON MATCHING TASK, MAT:A

(a) NORMAL SUBJECTS

GROUP	1	2	3	4	5	6
MAT: A SCORES	0-1	2	3	4	5	6
N	12	21	10	25	33	61
MATCHING X	6.64	5.18	5.47	5.07	5.29	5.14
(MAT:T) s.d.	2.67	0.67	0.47	0.58	0.77	2.25
MEMORY X	4.85	3.63	3.36	3.58	3.62	3.47
(MEM:T) s.d.	1.85	0.52	0.41	0.70	0.74	1.57

(b) DOWN SYNDROME SUBJECTS

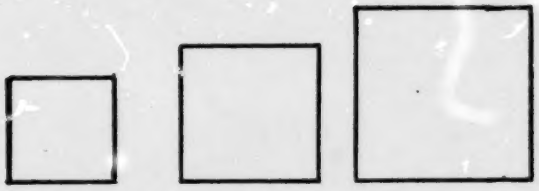
GROUP	1	2	3	4	5	6
MAT:A SCORES	0-1	2	3	4	5	6
N	3	19	24	24	19	38
MATCHING X	9.87	8.99	8.94	9.40	9.71	11.91
(MAT:T) s.d.	4.29	3.63	3.27	2.84	3.25	18.27
MEMORY X	9.17	6.89	8.02	7.24	7.44	8.43
(MEM:T) s.d.	4.23	2.54	4.64	2.69	3.29	13.44

Diagram 1

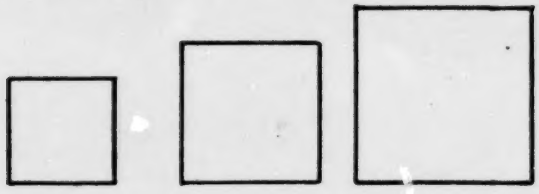
Diagrams illustrating the two experiments, MAT:A and MEM:A and MAT:T and MEM:T

MAT:A MEM:A

Diagram A



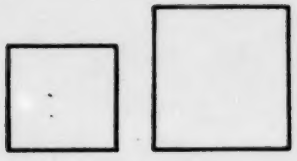
STIMULUS



CORRECT RESPONSE

MAT:T MEM:T

Diagram T



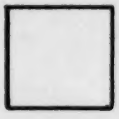


FIGURE 1.

RELATIONSHIP BETWEEN TIMES TAKEN TO PERFORM MATCHING : T AND MEMORY : T TASKS AND CHRONOLOGICAL AGE

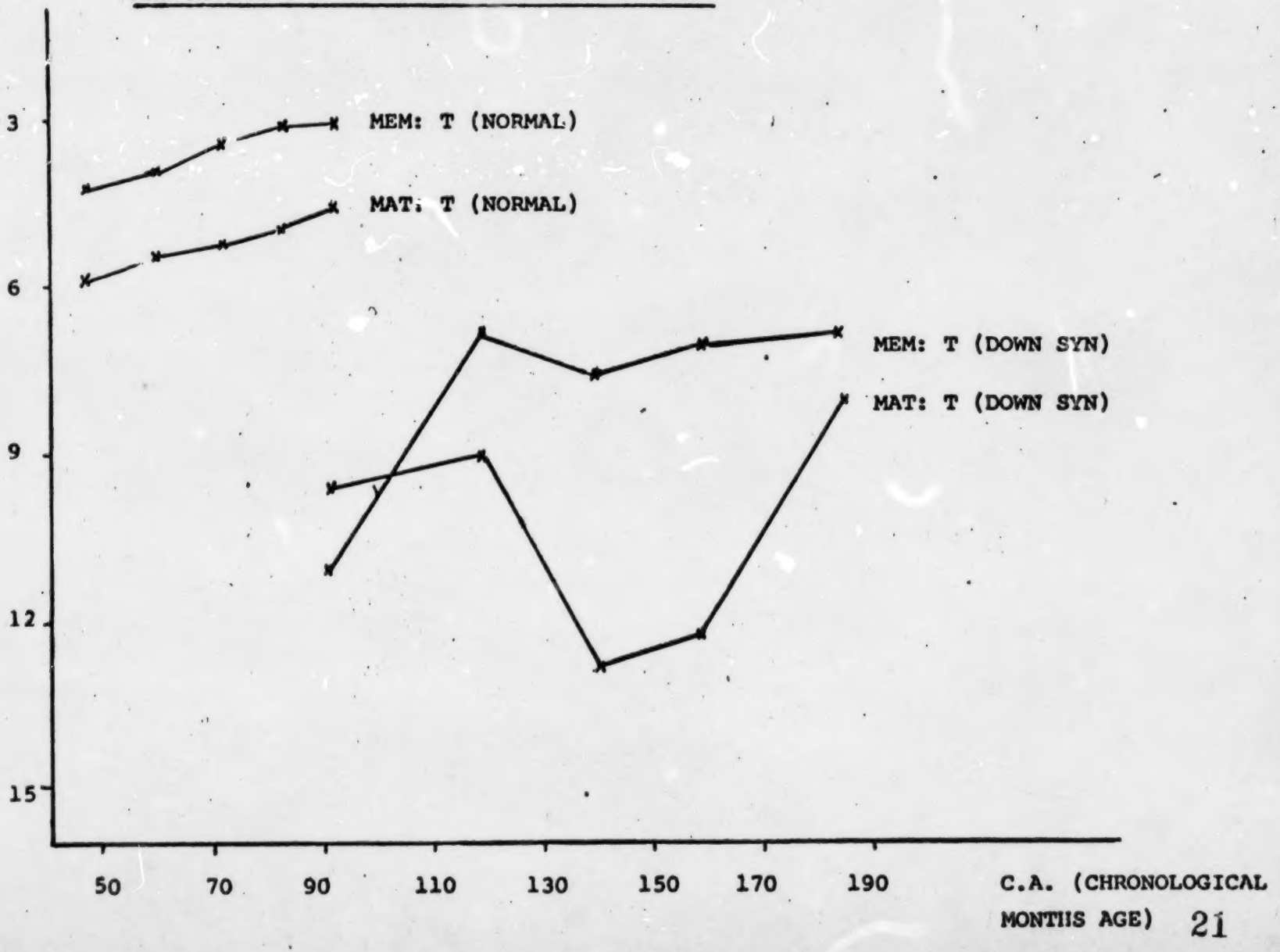


FIGURE 2.

RELATIONSHIP BETWEEN TIMES TAKEN TO PERFORM MAT: T AND MEM: T TASKS AND MENTAL AGE (MATCHING) (MEMORY)

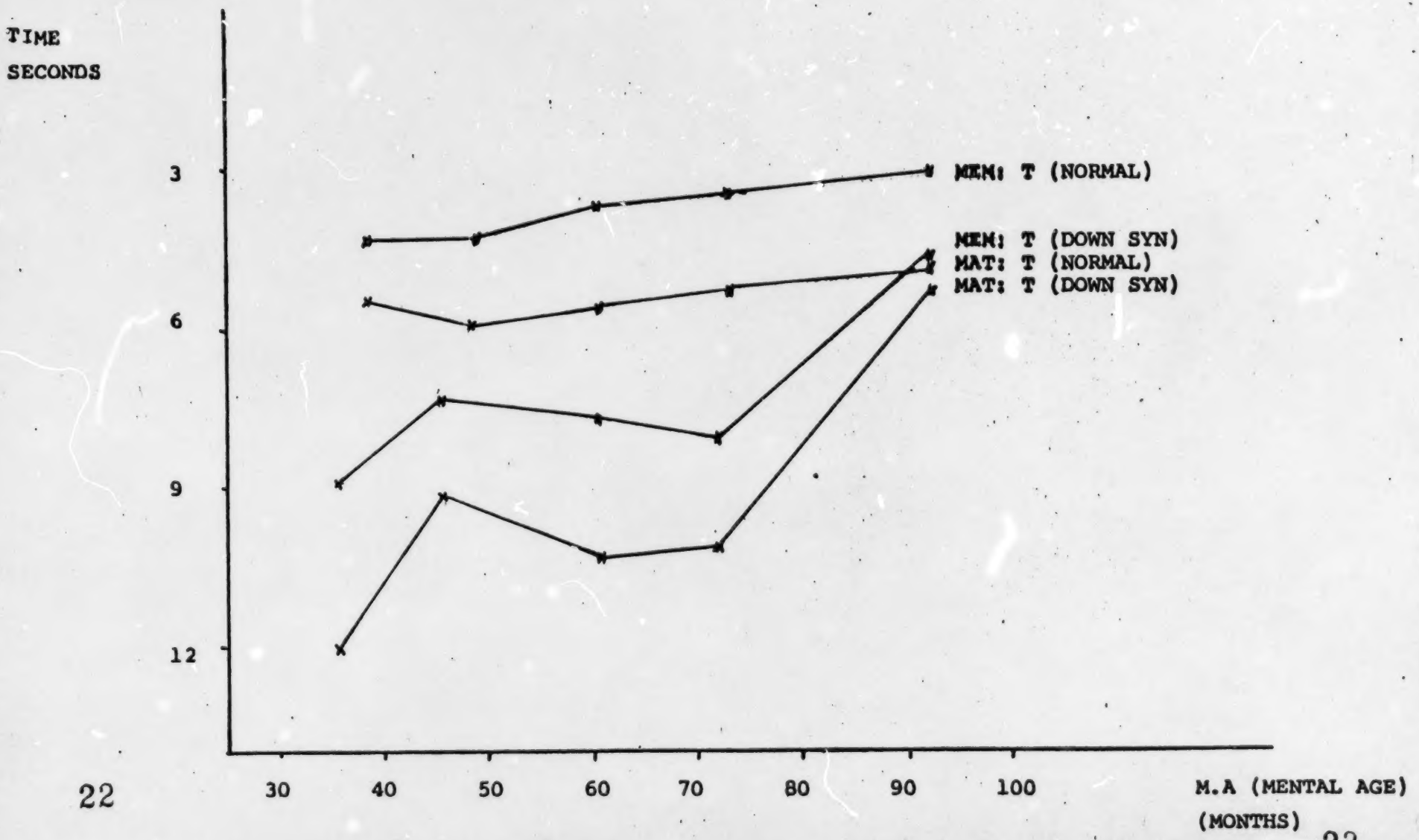


FIGURE 3.

RELATIONSHIPS BETWEEN TIMES TAKEN TO PERFORM MAT:T AND MEM: T TASKS AND SCORES (TOTAL ORDERS CORRECT) ON MEM: A TASK.

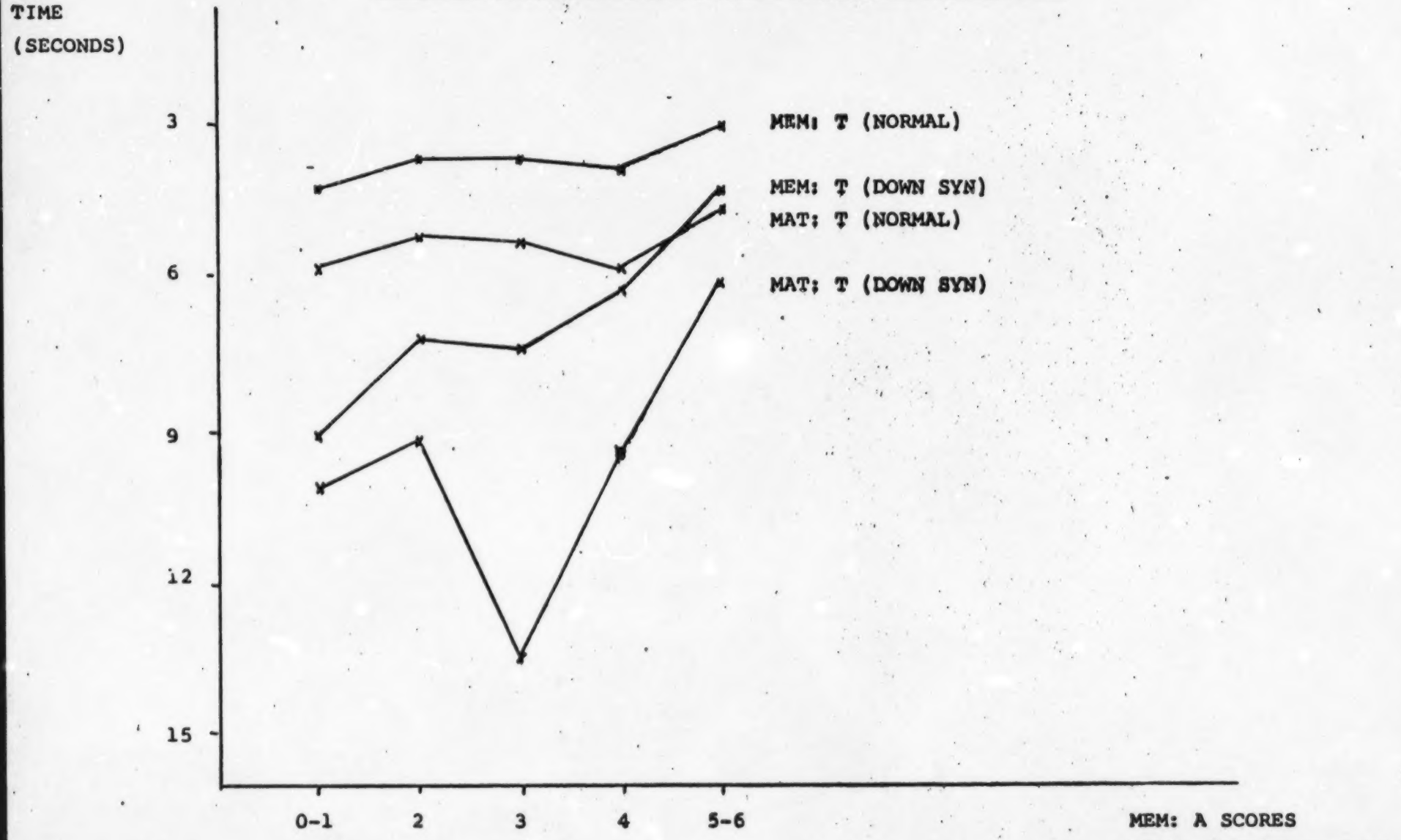
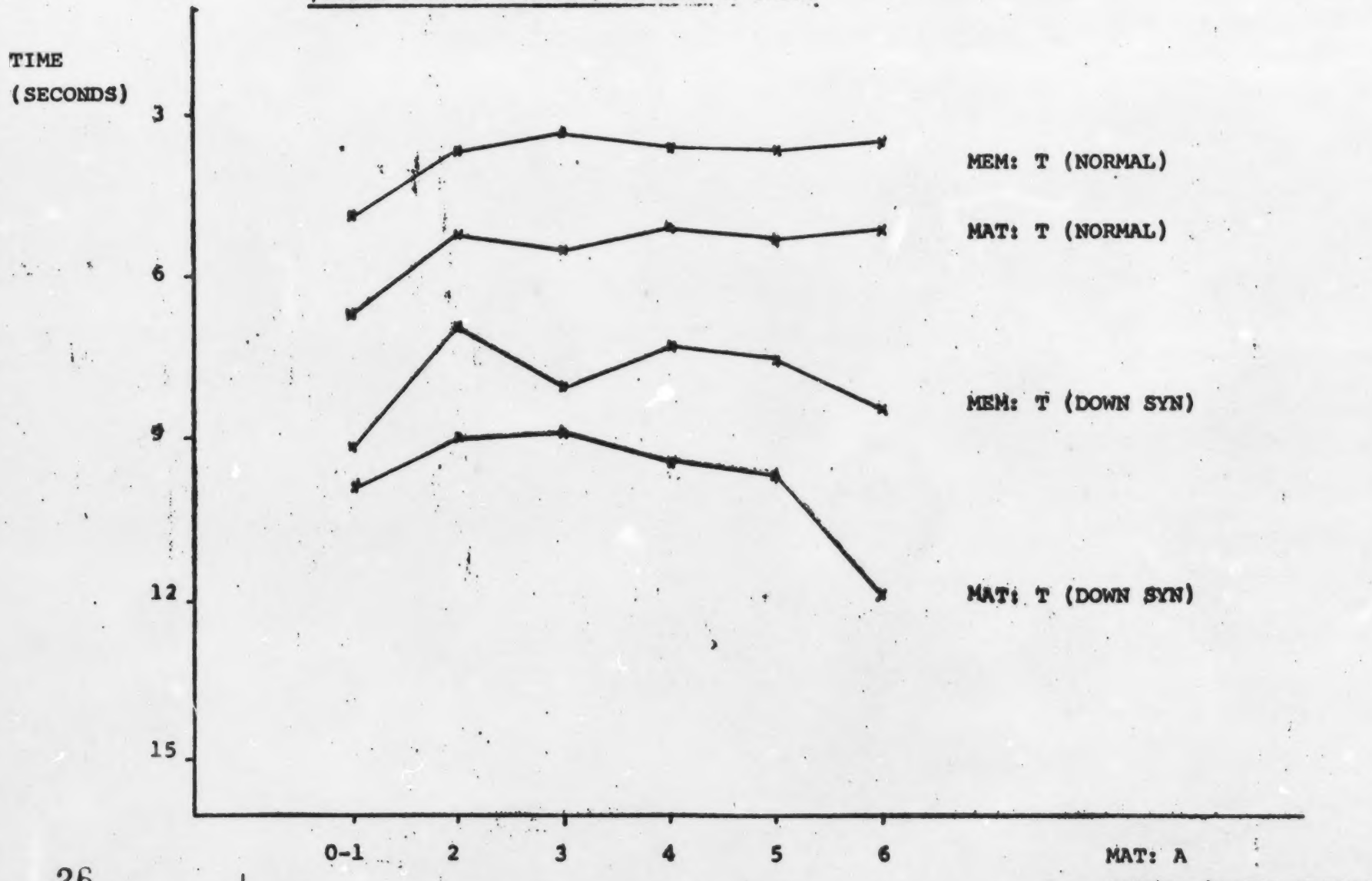


FIGURE 4. RELATIONSHIP BETWEEN TIMES TAKEN TO PERFORM MAT: T AND MEM: T TASKS AND SCORES (TOTAL ORDERS CORRECT) ON MAT: A TASK.



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